Comprehensive Analysis of Water Resource Challenges and Management Strategies in Rajasthan, India

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Abstract

Water is a natural resource that is essential to survival, income, food security, and long-term growth. Earth, which formerly had an ample supply of clean, drinkable water, is rapidly becoming a world with limited water due to overuse, abuse, and poor water management. The only way to preserve human existence on Earth is through the management of water resources, which is vitally necessary. The largest state in India is called Rajasthan, and it experiences tropical desert weather. The majority of the state's resources are derived from groundwater, with little surface water available. Groundwater sources provide 91% of the domestic water needed, with surface water sources providing only 9% of the total. In the state, low precipitation leads to low aquifer recharge and high evapotranspiration, which in turn causes water-related problems. In the state, the pattern of rainfall varies greatly and is unpredictable. For the previous sixty years, the state has frequently experienced drought and hunger. Population expansion, the green revolution, rapid industrial growth, urbanization, and shifting living standards are all contributing factors to the faster-than-average increase in water demand. In addition, overuse, logging, salinity, and nitrate and fluoride contamination are issues Rajasthan's water resources face. This study focused on different uses and how they can affect Rajasthan's water resources. This article also discusses a few potential fixes for these issues.

Keywords: Contamination, management, hydrogeology, and evapotranspiration.

Introduction:

Water is a natural resource that is essential to survival, income, food security, and long-term growth. In fact, water is the most basic element for human life and is required for all activities, including drinking, household use, industrial and agricultural use, and related fields. It also plays a critical role in the growth of a nation's or region's economy. Claiming that life on Earth is impossible without water would not be an exaggeration.

The modern world is facing a serious problem with a rapidly growing lack of water. People now have to rely on water from other sources because the situation has gotten so bad that groundwater has practically dried up in several nations. Furthermore, of the resources we still waste, water is one of the most overused. Although our lives revolve around it, our attention is not centered around it.

Because of excessive exploitation, overuse, and poor water management, the planet Earth, which formerly had an ample supply of clean and drinkable water, is rapidly becoming a water-scarce planet. When water was scarce, people made plans for it and valued it highly. Water is another reason why numerous civilizations flourish and fail. Despite our current understanding, we are still unable to fully appreciate the importance of water. So, the only thing that can save human existence on Earth is to manage water resources, which is vitally essential.

Planned, developed, distributed, and managed optimal use of water resources is known as water resource management. That falls under the category of water cycle management. This article focused on the different uses and how they can affect Rajasthan state's water supplies. This also includes a description of some potential fixes for these issues.

Objective:

This study's goal is to showcase Rajasthan's numerous initiatives for managing and using water resources, as well as to determine any potential effects these initiatives may have on the region's water supplies and offer recommendations for mitigating or controlling pollution-related issues. Study Area:

Arranging from 23^{0} 03' to 30^{0} 12' North latitude and 69^{0} 30' to 78^{0} 17' East longitude, Rajasthan is the largest state in terms of area in the nation. It is situated in the northwest. Approximately 10.4% of India's total land area, or 342,239 square kilometers, are covered by it. Along with five states—Punjab to the north, Uttar Pradesh and Haryana to the northeast, Madhya Pradesh to the southeast, and Gujarat to the southwest—it shares an international boundary with Pakistan. In fig. No.01, an administrative district boundary is displayed.

Figure 1: Administrative Divisions of Rajasthan

The climate of Rajasthan is tropical desert. From October to February, it stays extremely cold, and from March to September, the sun's scorching heat is felt. Rajasthan experiences little rainfall, which contributes to the state's dryness. In Rajasthan, summertime temperatures are quite high, with maximums of 49°C and lowests of 32°C. The state of Rajasthan has different amounts of rainfall, much like the climate.

With its nine agroclimatic zones and diverse soil types that aid in crop development, Rajasthan boasts an agricultural economy centered around agriculture. As per the Census 2011 report, around 62% of the State's population depends on agriculture and related sectors for their livelihood, with 75% of the population living in rural areas. It is one of India's major mineral-producing states. Rajasthan has 68,548,437 people living there as of the 2011 Indian Census. The state's population density is 200 people per km^2.Between 2001 and 2011, the population grew at a pace of 21.31%. In the state, there are 928 females for every 1000 males, and 66.11% of people are literate.

Methodology:

Secondary data sources have been heavily utilised in the study work to achieve its goal. Various governmental organizations, non-governmental organizations, and online sources have provided the data. In order to assess and determine the existing state of the water resources in the area and forecast some effects of various anthropogenic activities, pertinent data has been reviewed.

Water Resources:

Every body of water that builds up on the surface of the planet, including rivers, lakes, marshes, and seas, is referred to as surface water. Seepage or evapotranspiration depletes these resources, while precipitation replenishes them. Of India's surface water resources, Rajasthan has only 1.16 percent, or 21.71 billion cubic meters (BCM), while being known for its acute climate sensitivity and weak adaptation potential. The state can harvest and store almost 70% of the available water, as evidenced by the 16.05 billion cubic meters of economically exploitable resources contained within this. Furthermore, out of all the groundwater in the nation, 1.72 percent, or 11.36 BCM, is found in Rajasthan.

River inflows are the state's main source of challenge, as interstate accords allocate about 17.88 billion cubic meters (BCM). However, the political situation in the upper riparian states casts doubt on the reliability of these agreements. Though, theoretically, water consumption would rise by thirty percent, a more practical analysis indicates that economically useable water might only rise by twenty-one percent, meaning that 79 percent of the 45.09 billion cubic meters of total available water would be used.

All the rivers in Rajasthan are seasonal; all but the Chambal run only during the wet season. The development of these river catchment basins is greatly influenced by precipitation and topography. The highly divided, rough, and rolling uplands that give rise to the streams that eventually become the rivers are what cause the catchments to have low stream densities.

The Luni River is the only river that flows west of the Aravallis, and the Aravalli Range is Rajasthan's main water divide. The western part of the state, which makes up around 60% of its total land, has internal drainage, with streams disappearing into the desert sands after only a brief distance. The actual Luni River is a transient stream that experiences a flood cycle every sixteen years. By contrast, the major drainage of the eastern region, east of the Aravalli hills, flows towards the northeast for a distance of around 226 km. The southeast part of Rajasthan is drained by the Chambal River, which rises in the Aravalli Range and has the Banas as a tributary.

Important catchments like the Yamuna-Ganga in the northeast and the Sabarmati and Mahi in the southwest are located in the northern and northeastern parts of eastern Rajasthan. The interior rivers of Sota, Kantli, Barah, Banganga, and Sahibi are essential to the drainage system of eastern Rajasthan, which is often dendritic in form.

Numerous salt lakes may be found in Rajasthan's desert region, including the well-known Pokran, Sambhar Lake, Bap, Didwana Lake, Rann of Jaisalmer, and Pachpadra. As part of interstate agreements, Rajasthan also receives water from interstate river basins.

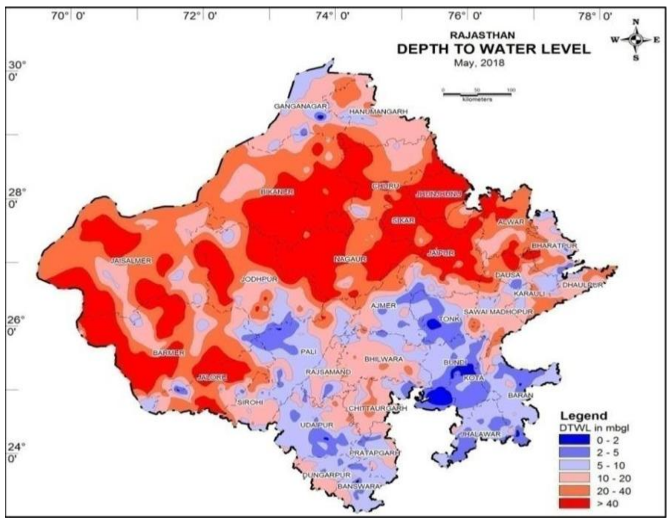
During the past 50 years, the State government of Rajasthan has given considerable priority to the development of the state's surface water resources, which has resulted in the planning and execution of multiple irrigation projects around the state. The Indira Gandhi Nahar Pariyojana (IGNP), the Mahi Bajaj Sagar Project, the Bisalpur Project, the Jakham Irrigation Project, and the Gurgaon Canal Project are a few of Rajasthan's noteworthy irrigation initiatives. These projects' main goals are to supply drinking water and support agricultural activity. The IGNP covers the districts of Bikaner, Jaisalmer, Ganganagar, and Hanumangarh in Rajasthan.

Three separate hydrogeological units—unconsolidated sediments, semi-consolidated sediments, and consolidated rocks—are revealed by an analysis of groundwater occurrence and flow in Rajasthan. Silt, gravel, sand, clay, and mixed calculus make up the Quaternary sediments, which include both older and younger alluvium. Because of their broad occurrence, these sediments are very significant. Potential aquifers are produced in different regions of the state by gravel, sand, and mixed formations; at Anupgarh, Ganganagar district, the maximum alluvium thickness was measured at 543.51 mbgl.

Furthermore, the semi-consolidated formations, which are defined by siltstone, claystone, shale, and conglomerate limestone, are important because, in some places, sandstones and limestones serve as the main aquifers. In the districts of Barmer, Jaisalmer, and Jodhpur, specifically, the sandstones of the Lathi formation are acknowledged as the most powerful aquifers. The cemented rocks, on the other hand, are mostly found in the eastern region of Rajasthan and include gneiss, marble, granites, schist, Vindhyan limestone, phyllites, basaltic flows, sandstones, and quartzite. Unless wells are positioned close to significant lineaments or other weak planes, the yield potential in these formations is restricted. At deeper levels, nevertheless, the quality of the groundwater is typically poor, ranging from brackish to saltwater.

There is a significant amount of regional variance in Rajasthan's water level depth. It has been observed that the canal command regions in the districts of Ganganagar, Bundi, Banswara, and Kota have shallow water levels. In contrast, the western districts— Bikaner, Barmer, Jodhpur, and Jaisalmer—have deeper water levels. The depth to-water level map for the pre-monsoon period (May 2018) is shown in Figure No. 02, where the eastern Aravallis has shallower water levels than the western Aravallis. The water's depth fluctuates between 20 and 80 meters in the west and less than 10 to 25 meters in the east of the Aravallis. On the east and southeast face of the Aravallis, the water's slope trends in that direction; on the west and northwest face, it does the opposite. Notably, groundwater circulation and direction may vary locally. Aquifer depletion in various parts of the state could result from overuse and exploitation of groundwater, which has caused a notable drop in water levels.

Fig.1: Depth to Water Level in Rajasthan,



Source: CGWB

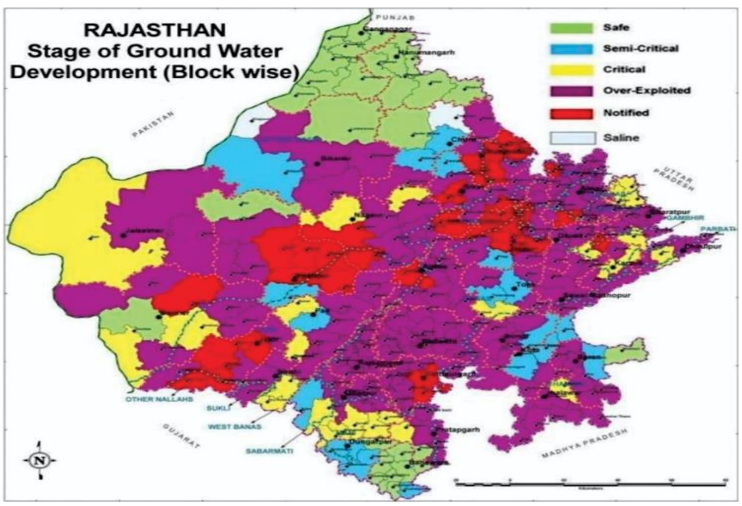
Following the monsoon, Rajasthan's groundwater levels are analyzed and the results show a moderate rise in the eastern and western regions, with negligible increases or generally stable water levels in the western region.

An estimate of one to three meters is the yearly decline of water table in Rajasthan. The gross groundwater draw for all purposes in the state is currently 15.7059976 BCM, while the net groundwater availability is at 11.2567695 BCM. Requirements for irrigation total 0.9031139 BCM, whereas the allotted water for residential and commercial use is 2.3151773 BCM. This has led to an alarming 139.52% of the state's groundwater development occurring overall.

When one examines the development of groundwater in Rajasthan's various districts more closely, one finds alarming results. At 200 percent of the yearly recharge, Jhunjhunu has the highest level of over-exploitation, whereas Jaipur has a groundwater development stage of 186.6%. There is extensive usage and exploitation of groundwater in areas that are supported by aquifers of semi-consolidated sandstone, limestone, and alluvium. On the other hand, areas with crystalline rock underlayment have restricted static groundwater supplies, are very unlikely to be overfished and cause wells to dry up during an overdraft.

At barely 45% of their potential, Ganganagar district's groundwater resources are the least developed. On the other hand, this occurrence might have been exacerbated by the canal water present here. Figure No. 03 provides more details on the block-by-block groundwater development state.

Fig. 3: Ground water development map of Rajasthan



Source: Hydrogeological atlas of Rajasthan.

Rajasthan is mostly dependent on groundwater; the state does not rely much on surface water supplies. More specifically, groundwater supplies provide water for 91% of household needs, 80% of irrigation water demands, and most industrial water needs. Surface water sources provide just 9 percent of the required amount of water. Meeting the varying demands of various sectors and providing a secure water supply for the populace pose substantial issues for planners in the state, given the historical incidence of recurrent droughts and famines over the past 60 years.

Numerous problems plague Rajasthan's water supply, including overuse, salinity, waterlogging, and fluoride and nitrate contamination in different districts:

Overexploitation: Rajasthan's growing urbanization, industrialization, and population have all contributed to a steady increase in groundwater extraction. A further factor contributing to the overuse of groundwater is the unequal distribution and restricted availability of surface water supplies. 184 of the state's 295 total blocks are estimated to be overexploited, 34 to be critical, 29 to be semi-critical, and 3 to be saline. Though they are in areas under canal command, have low quality, or have deep water levels, the remaining 45 blocks are safe but have restrictions on groundwater development.

Arsenic Contamination: The World Health Organization's (WHO) safety criteria for arsenic content have been discovered to be exceeded in the groundwater in four districts: Churu, Sikar, Gangapur, and Hanumangarh. Arsenic has also been detected in the mining regions of the Zawar mines in Jhunjhunu and Udaipur districts, as well as the Khetri Copper Complex, suggesting localized pollution brought on by mining activity.

Fluoride Contamination: Of all the Indian states, Rajasthan is the only one where nearly every district is impacted by elevated levels of fluoride in the groundwater. Thirty of the thirty-three districts are specifically considered to be contaminated with fluoride. With nearly 45 lakh people living in 6,589 habitations where fluoride is a problem, this problem affects a sizeable section of the state's population. The districts of Pali, Ajmer, Jalore, Sirohi, Nagur, Jaipur, and Jodhpur have the greatest levels of fluoride contamination, which is especially prevalent in the Thar Desert region. The state's fluoride-rich rock formations are a contributing factor to groundwater contamination, which causes widespread fluorosis and related skeletal and dental disorders. Weathering of rocks, precipitation, and unclean water from fertilizers and waste runoff all contribute to the introduction of fluoride into the soil.

Nitrate contamination: Due to the extensive use of nitrogen fertilizers, irrigation of household wastewater, and application of manure, nitrate pollution has become a significant environmental and health concern in Rajasthan. This issue is made worse by low rainfall, which results in lower dilution effects and increased nitrate concentrations in groundwater. High nitrate levels plague most of Rajasthan; a number of districts, notably Sikar, Ajmer, Churu, Jaisalmer, Sawai Madhopur, Bharatpur, Jalore, Jodhpur, Jaipur, Nagaur, Sirohi, Udaipur, Jhalawar, Tonk, and Barmer, are particularly hard hit. High nitrate levels in drinking water have been connected to a number of illnesses, including multiple sclerosis, methemoglobinemia, Alzheimer's disease, vascular dementia, and gastrointestinal malignancies.

Water logging: The Chambal basin in Rajasthan as well as places outside the basin are seriously threatened by water logging. The main causes of it are excessive irrigation in the Chambal basin and canal seepage in the outer basin. As a result, 145,600 hectares of affected land are in a critical situation, with the water table being only six meters below the surface of the field. Experts expect that hundreds of hectares of land will be submerged in 25 to 30 years, making the second stage of the

Indira Gandhi Nahar Pariyojana (IGNP) an even more significant worry.

Salinity: Rajasthan, the biggest state in India, faces a substantial amount of saline groundwater, especially in its western parts, which cover an area of roughly 97,673.13 square kilometers over 16 districts. 3,053.38 million cubic meters (MCM) of total salty groundwater are estimated to be available in the state, with a gross draft of 592.75 MCM. district-specific salinity data (bad quality).

Conclusion and suggestions:

Arid and semi-arid regions now face severe water resource shortages and declining water quality as a result of variables like climate change, population increase, urban and industrial development, and environmental degradation. Mitigating unsanitary conditions and mismanagement of water resources can be achieved by implementing suitable wastewater treatment systems and optimizing the utilization of treated wastewater.

Important for maintaining life and the ecosystem, water is a limited but necessary resource. Sustaining its availability and sustainability for future generations requires good management due to shifting demographics and rising demand. Several findings and suggestions have been drawn from the current investigation, including:

1. Because of low precipitation, increased evapotranspiration, irregular rainfall patterns, and decreased aquifer recharging, Rajasthan faces water-related issues.

2. The most dependable and dependable source of life support in the state is still the groundwater resources, notwithstanding their low quality and limited amount.

Effective water management and regulation are required due to the increasing demand for water resulting from population increase, industrialization, and urbanization.

4. Degradation of water quality and falling water levels are being caused by the steady rise in groundwater extraction brought on by industrialization and population growth.

5. Strategies for managing and regulating groundwater must be enforced immediately, particularly in regions that are considered overexploited.

6. In order to maintain and safeguard groundwater reservoirs, appropriate procedures and regulations are needed to address groundwater level reductions in both hard rock and alluvial locations.

7. To save water supplies, urban wastewater must be reused and recycled for industrial and irrigation uses.

8. In regions susceptible to water-logging, it is essential to implement enhanced irrigation techniques, modified crop rotation strategies, and regulated canal outflow of water.

9. Proactively promoting organized sewage systems and teaching communities about the need of hygiene maintenance are two ways to combat the rising nitrate levels in groundwater.

10. Assuring sustainable water resources requires public education and participation in water management techniques, conservation, protection, and development.

11. In overexploited areas, it is imperative to implement workable plans for rainfall gathering and artificial recharge structures.

12. Sustainable water management at the village, district, and state levels depends on strict attention to water security planning and implementation.

13. In water-stressed areas, encouraging the use of sprinkler and drip irrigation systems can help save water.

14. Because of the erratic and seasonal nature of rainfall, it is imperative to build water reservoirs, such as dams, tanks, and ponds, in order to retain rainfall water and fulfill yearly demands for drinking and agriculture.

If these suggestions are carried out successfully, they can help Rajasthan manage its water resources sustainably and conserve them by tackling issues like overuse, deteriorating quality, and scarcity.

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